19-577-100 **April 24, 2020**

Rob Russell, MCIP, RPP
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Georgetown, ON, L7G 2B3

Via email: rob.russell@russellplanning.com

Re: Water Balance Investigation
Graham Property- Corner of Highway nine (9) and Mount Pleasant Road, Caledon, Ontario

1.0 INTRODUCTION

DS Consultants Ltd. (DS) was retained by Rob Russell Planning Consultants Inc. to complete a water balance study for the Property located at the southeast corner of Highway nine (9) and Mount Pleasant Road in Palgrave, Ontario (Site). The Site is currently used as agricultural land and includes one residential dwelling. The Site is proposed to be developed as a residential subdivision with twenty-two (22) estate-style lots occupying an area of about 30,174 m^2 (30.2 ha). A variety of Low Impact Development (LID) measures are also proposed at the Site to responsibly manage stormwater. To inform the design of LIDs, a Thornthwaite Monthly Water Balance Model was completed and used to evaluate pre-development and post-development hydrological conditions at the Site. The results can be used to design appropriate LID measures to compensate for any anticipated changes in site hydrology.

2.0 WATER BALANCE ASSESSMENT

2.1 Existing Conditions (Pre-Development)

The subject Site has a total area of 302,000 m^2 and includes one (1) existing residential dwelling with approximate impervious areas totalling 700 m^2 (building) and 1300 m^2(asphalt/paved surface). The remainder of the Site is pervious area consisting of about 236,000 m^2 agricultural land, 30,500 m^2 forests, 10,500 m^2 landscape and 23,000 m^2 pasture and shrubs. Pre-development land use is summarised in **Table 2.1**. **Figure 1** shows the pre-development conceptual model considered for establishing current hydrologic conditions.

2.2 Proposed Development (Post-Development)

The proposed area for subdivision is 302,000 m^2 with Low Impact Development (LID) measures. For the water balance calculations in this report, it is estimated that the proposed subdivision will include residential dwellings with a combined roof area of about 14000 m^2 and a paved surface area of about 18,000 m^2 and the remaining area of 270,000 m^2 will be developed as a pervious area with LID measures. Out of the total pervious area, 149,000 m^2 will be an open space(forests). Post-development land use is summarised in **Table 2.1**. **Figure 2** shows the post-development conceptual model considered for establishing post-hydrologic conditions.

Table 2.1: Pre-Development and Post- Development Land Use

Total Site Area(m^2)- 302,000 (30.2 ha)	Pre-Development	Post-Development
Impervious Area		
Buildings (m^2)	700	14,000
Driveways/Roads (m^2)	1300	18,000
Pervious Area		
Open Space-Agriculture Land (m^2)	236,000	0
Open Space- Pasture/Shrubs (m^2)	23,000	0
Open Space- Forests(m^2)	30,500	149,000
Urban Lawn/Landscape (m^2)	10,500	121,000
Total	302,000	302,000

2.3 Water Balance Components (Thornthwaite Monthly Water Balance Model)

The Thornthwaite water balance (Thornthwaite, 1948; Mather, 1978; 1979) is an accounting type method used to analyze the allocation of water among various components of the hydrologic cycle. Inputs to the model are monthly temperature, Site latitude, precipitation, and stormwater run-on. Outputs include monthly potential and actual evapotranspiration, evaporation, water surplus, total infiltration, and total runoff. For ease of calculation, a spreadsheet model was used for the computation.

When precipitation (P) occurs, it can either runoff (R) through the surface water system, infiltrate (I) to the water table, or evaporate/evapotranspiration (ET) from the earth's surface and vegetation. The sum of R and I is termed as the water surplus (S). When long-term averages of P, R, I and ET are used, there is no net change in groundwater storage (ST). Annually, however, there is a potential for minor changes in ST. The annual water budget can be stated as **P = ET + R + I + ST** and the components are discussed below.

Precipitation (P)

Based on the 30-year average for Albion Field Centre Climate Station in Ontario, the average precipitation for the area is about 821.4 mm/year for the period between 1981 and 2010. Also, the average monthly temperature from this station has been used. The monthly distribution of precipitation is presented in **Table A1, Appendix A.**

Storage (ST)

Groundwater storage (ST) of native soils for the existing Site was estimated using values of Water Holding Capacity (mm) of respective land use and soil types identified in Table 3.1 of the Storm

Water Management (SWM) Planning & Design Manual (MOE, March 2003). The land uses, soil types and respective water holding capacities shown in **Table 2.2** were chosen to represent existing conditions and applied to March for monthly calculations.

Table 2.2: Water Holding Capacity of Native Soils in Pervious Areas

Land Uses	Soil Types	Water Holding Capacity (mm/year)	
		Pre-Development	Post-Development
Agriculture land- Moderately Rooted Crops	Fine Sandy Loam	150	-
Pasture and Shrubs	Fine Sandy Loam	150	-
Mature Forests	Fine Sandy Loam	300	300
Landscape/Urban Lawn	Clay Loam	100	100

Using the procedures outlined in the SWM Planning & Design Manual for the above land use and soil type, the annual change in storage is zero (0).

Evapotranspiration (ET)

Monthly Potential Evapotranspiration (PET) is estimated using monthly temperature data and is defined as a water loss from a homogeneous vegetation-covered area that never lacks water (Thornthwaite,1948; Mather, 1978). In the Thornthwaite water balance model, PET is calculated using the Hamon equation (Hamon, 1061);

PET Hamon = 13.97 * d * D2 * Wt

Where:

d = the number of days in the month

D = the mean monthly hours of daylight in units of 12 hours

Wt = a saturated water vapour density term = 4.95 * e0.627/100

T = the monthly mean temperature in degrees Celsius

The calculated Actual Evapotranspiration (AET) is based on PET and changes in ST (Δ ST). Where there is not enough P to satisfy PET, a reduction in ST occurs. As a result, volumes of AET are less than PET. Also, it is assumed that evaporation will occur and will amount to 15% of the total precipitation for an impervious cover.

Precipitation Surplus (S)

Precipitation surplus is calculated as P–ET. For pervious areas, ET is considered AET and for impervious areas, ET is evaporation.

Infiltration (I) and Runoff (R)

For pervious areas, precipitation surplus has two components in the Thornthwaite model: a runoff component (overland flow that occurs when soil moisture capacity is exceeded) and an infiltration component. The accumulation of infiltration factors for topography, soil types and the cover as prescribed in Table 3.2 of the SWM Planning & Design Manual give infiltration factors for existing conditions on the Site as shown below in **Table 2.3**. The runoff component calculated in the pre-development and post-development is the remaining volume of precipitation surplus following AET, ET and infiltration.

Table 2.3: Pre-Development and Post-Development Conditions – Infiltration Factors

Land Uses	Topography	Soil	Cover	Total Infiltration	Total Runoff/Surplus Water
Pre- Development Conditions					
Agriculture Land	0.1	0.3	0.1	0.5	0.5
Pasture and Shrubs	0.2	0.3	0.1	0.6	0.4
Landscaped Area	0.2	0.2	0.1	0.5	0.5
Forests	0.1	0.3	0.2	0.6	0.4
Post- Development Conditions					
Forests	0.1	0.3	0.2	0.6	0.4
Landscaped Area	0.2	0.2	0.1	*0.45	0.55
Note: *(includes 10 % reduction in infiltration due to compaction from construction)					

2.4 Water Balance Analysis

To predict outputs of the pre-development and post-development water balance, various inputs were entered into the Thornthwaite model including monthly precipitation and temperature, Site latitude, water holding capacity values for native soils and factors of infiltration as discussed in section 4.3. The analysis is summarised below, and the detailed calculations are presented in **Table A 1-3, Appendix A.**

2.4.1 Water Balance- Pre-Development

The average precipitation for the area is about 821.4 mm/year. For the pervious area, the calculated PET is 581 mm/year or about 71% of the total precipitation. The monthly distribution of ST for the pervious area in silty sand soils produced a unit area annual AET of 533 mm/year for the impervious areas, it is assumed that evaporation will occur and will amount to 15% of total precipitation (698 mm/year). Given a total pervious area of 300,000 m^2 and an impervious area of 2,000 m^2, the existing development will produce an evapotranspiration/AET 160,655 m^3/year, an infiltration 44,475 m^3/year and a runoff 42,932 m^3/year. The analysis is summarised as below in **Table 2.4**. The detailed calculations are presented in **Table A-2, Appendix A.**

Table 2.4: Summary of Water Balance- Pre-Development Land Use

Characteristic	Area	Evaporation/AET m^3/year	Infiltration m^3/year	Runoff m^3/year
Total Proposed Development Area (m^2)- 302,000				
Pervious Area				
Open Space-Agriculture Land (m^2)	236,000	125,776	34,036	34,036
Open Space-Forests(m^2)	30,500	12,258	4,836	3,224
Open Space- Landscape(m^2)	10,500	5,382	1,622	1,622
Open Space- Pasture/Shrubs(m^2)	23,000	16,993	3,981	2,654
Impervious Area				
Building/Driveway(m^2)	2,000	246	0	1,396
Total Post- Development Area- (m^2)	**302,000**	**160,655**	**44,475**	**42,932**

2.4.2 Water Balance- Post-Development

In the post-construction scenario, changes in land use will result in about 18,000 m^2 of paved surfaces, 14,000 m^2 of buildings and 270,000 m^2 of pervious areas (landscaped and open space /undeveloped area). The monthly distribution of ST for a landscaped area in silty clay soils and open space in silty sand soils produced a unit area annual AET of 533 mm/year and 513 mm/year, respectively. For the impervious areas, it is assumed that evaporation will occur and will amount to 15% of total precipitation (698 mm/year). Given a total pervious area of 270,000 m^2 and an impervious area of 32,000 m^2, the proposed development will produce an evapotranspiration/AET 148,974 m^3/year, an infiltration 40,442 m^3/year and a runoff 58,646 m^3/year. The analysis is summarised as below in **Table 2.5.** The detailed calculations are presented in **Table A-3, Appendix A.**

Table 2.5: Summary of Water Balance- Post-Development Land Use

Characteristic	Area	Evaporation/AET m^3/year	Infiltration m^3/year	Runoff m^3/year
Pervious Area				
Open Space-Forests (m^2)	149,000	83,014	23,625	15,750
Urban Lawn/Landscape (m^2)	121,000	62,017	16,817	20,554
Impervious Area				
Buildings (Roofs) (m^2)	14,000	1,725	0	9,775
Roads/ Driveways/Paved Surface (m^2)	18,000	2,218	0	12,567
Total Post-Development Area (m^2)	**302,000**	**148,974**	**40,442**	**58,646**

2.4.3 Water Balance Results - Pre-Development to Post- Development Changes

Based on the results of the pre-development and post-development water balance completed, the proposed development will produce a reduction in annual evapotranspiration/AET(11,681 m^3/year), a reduction in annual infiltration (4033 m^3/year) and an increase in annual runoff (15714 m^3/year). The effects are the result of increased impervious area, replacing pervious areas of the Site. To maintain pre-development water balance, various LID measures will be considered during design. Infiltration galleries and SWM are proposed at the site to promote infiltration and minimize runoff. The analysis is summarised as below in Table 2.6. The detailed calculations are presented in Table A-1 to 3, Appendix A.

Table 2.6: Summary of Water Balance- Pre-Development and Post-Development Land Use

Characteristic	Pre-Development	Post-Development (no mitigation)	Change (Pre- to Post-Development)
Total Area (m^2)	302,000	302,000	**0**
Pervious Area (m^2)	300,000	270,000	**-30,000**
Impervious Area (m^2)	2,000	32,000	**30,000**
Precipitation (m^3/year)	248,062	248,062	**0**
Total Evaporation/AET (m^3/year)	160,655	148,974	**-11,681**
Total Infiltration (m^3/year)	44,475	40,442	**-4,033**
Total Runoff (m^3/year)	42,932	58,646	**15,714**

3.0 CONCLUSIONS AND RECOMMENDATIONS

A water balance analysis was completed for the Site to estimate pre-development and post-development evaporation, infiltration and runoff for the proposed development. The following are our conclusions and recommendations based on water balance results.

- Based on the results of the pre-development and post-development water balance completed, the proposed development will produce a reduction in annual evapotranspiration **(11,681 m^3/year)**, a reduction in annual infiltration **(4033 m^3/year)** and an increase in annual runoff **(15,714 m^3/year)**. The effects are mainly the result of increased impervious area, replacing pervious areas of the Site.
- Low impact development (LID) measures will be considered during detail design to manage stormwater and minimize surface runoff and to promote infiltration.
- Considering the roof area (impervious) of the proposed development **(14,000 m^2)**, the estimated annual runoff produced from the roof area is **9,775 m^3/year**. There is enough clean water supply available to eliminate the infiltration deficit.

We trust this report satisfies your needs. If there are questions or you need more information, please do not hesitate to contact our office.

DS CONSULTANTS LTD

Prepared By:

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Hydrogeologist

Reviewed By:

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Attachments:

Figures:

Figure 1: Pre-Development Land Use
Figure 2: Post-Development Land Use

Appendix:

Appendix A: Water Balance Tables A 1 through A3

Figures

Total Site Area(ha)	30.2
Impervious Area	
Building(ha)	0.07
Driveway(ha)	0.13
Pervious Area	
Open Space-Agriculture Land(ha)	23.6
Open Space-Landscape(ha)	1.05
Open Space-Forest(ha)	3.05
Open Space-Pasture/Shrubs(ha)	2.3

Legend

- Approx. Site Boundary (30.2ha)
- Agricultural Land
- Building
- Driveway
- Pasture/Shrubs
- Forest
- Landscape

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Project: HYDROGEOLOGICAL INVESTIGATION
Graham Property, Palgrave, ON

Title: **PRE-DEVELOPMENT LAND USE**

Client: ROB RUSSELL PLANNING INC.

Size: 8.5 x 11	Approved By: P.P	Drawn By: S.Y	Date: April 2020
Rev: 0	Scale: As Shown	Project No.: 18-577-100	Figure No.: 1

Image/Map Source: *Google Satellite Image*

TOWN OF CALEDON PLANNING RECEIVED

May 04, 2020

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Total Site Area(ha)	30.2
Impervious Area	
Building(ha)	1.4
Driveways/Roads(ha)	1.8
Pervious Area	
Open Space - Urban Lawn/Landscape(ha)	12.1
Open Space - Forest(ha)	14.9

Legend

- Approx. Site Boundary (30.2ha)
- Building
- Driveway
- Road
- Urban Lawn/Landcape
- Forest

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Project: HYDROGEOLOGICAL INVESTIGATION
Graham Property, Palgrave, ON

Title: **POST-DEVELOPMENT LAND USE**

N

Client: ROB RUSSELL PLANNING INC.

Size: 8.5 x 11	Approved By: P.P	Drawn By: S.Y	Date: April 2020
Rev: 0	Scale: As Shown	Project No.: 18-577-100	Figure No.: 2

Image/Map Source: *Google Satellite Image*

Appendix A:
Water Balance Tables(A1-A3)

TABLE A-1

CLIMATE NORMALS 1981-2010 (ALBIAN FIELD CENTRE CLIMATE STATION)

Water Balance -Graham Property

	Thornthwaite (1948)					
Month	Mean Temperature (°C)	Heat Index	Unadjusted Potential Evapotranspiration (mm)	Daylight Correction Value	Adjusted Potential Evapotranspiration (mm)	Total Precipitation (mm)
January	-7.0	0.0	0.0	0.81	0.0	60.4
February	-5.9	0.0	0.0	0.82	0.0	50.2
March	-1.4	0.0	0.0	1.02	0.0	50.3
April	6.1	1.4	28.8	1.13	32.5	67.0
May	12.4	4.0	60.6	1.27	76.9	76.1
June	17.3	6.5	85.9	1.29	110.8	75.5
July	19.9	8.1	99.4	1.30	129.3	81.8
August	19.1	7.6	95.3	1.20	114.3	77.4
September	14.3	4.9	70.3	1.04	73.1	75.0
October	8.1	2.1	38.8	0.95	36.8	68.3
November	2.1	0.3	9.4	0.8	7.5	81.7
December	-3.9	0.0	0.0	0.76	0.0	57.7
TOTALS		**34.8**	**488.5**		**581.3**	**821.4**

Notes: Daylight Correction values obtained from Instruction and Tables For Computing Potential Evapotranspiration and The Water Balance (Thornthwaite & Mather, 1957)

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TABLE A-2

Pre-development Water Balance

Water Balance Analysis - Graham Property

Catchments and Hydrologic Components			March	April	May	June	July	August	September	October	November	December	January	February	Total
			Month												
		PET - Adjusted Potential Evapotranspiration (mm)	0	33	77	111	129	114	73	37	8	0	0	0	**581**
		P - Total Precipitation (mm)	50	67	76	76	82	77	75	68	82	58	60	50	**821**
		P-PET (mm)	50	34	-1	-35	-47	-37	2	31	74	58	60	50	-
		Soil Moisture Deficit (mm)	0	0	-1	-36	-84	-120	-119	-87	-13	0	0	0	-
Graham Property	Pervious Area-Agricultural Land-Moderately Rooted Crops-Fine Sandy Loam	**Soil Moisture Storage (mm)**	150	150	149	114	66	30	31	63	137	150	150	150	-
		Actual Potential Evapotranspiration (mm)	0	33	77	106	110	89	73	37	8	0	0	0	**533**
		P-AET (mm)	50	34	-1	-31	-29	-12	2	31	74	58	60	50	-
		Actual Soil Moisture Deficit (mm)	0	0	-1	-32	-60	-72	-70	-39	0	0	0	0	-
		Change in Soil Moisture Deficit (mm)	0	0	1	31	29	12	-2	-31	-39	0	0	0	-
		Precipitation Surplus (mm)	50	34	0	0	0	0	0	0	35	58	60	50	**288**
		MOECC Infiltration Factor	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
		Run-Off Coefficient	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	-
		Infiltration (mm)	25	17	0	0	0	0	0	0	18	29	30	25	**144**
		Run-Off (mm)	25	17	0	0	0	0	0	0	18	29	30	25	**144**
		Catchment Area (m^2) = 236000.00						**Subcatchment Monthly Volumes**							
		Infiltration (m^3)	5935	4066	0	0	0	0	0	0	4176	6809	7127	5924	**34037**
		Run-Off (m^3)	5935	4066	0	0	0	0	0	0	4176	6809	7127	5924	**34037**
	Pervious Area-Pasture and Shrubs-Fine Sandy Loam	**Soil Moisture Storage (mm)**	150	150	149	114	66	30	31	63	137	150	150	150	-
		Actual Potential Evapotranspiration (mm)	0	33	77	106	110	89	73	37	8	0	0	0	**533**
		P-AET (mm)	50	34	-1	-31	-29	-12	2	31	74	58	60	50	-
		Actual Soil Moisture Deficit (mm)	0	0	-1	-32	-60	-72	-70	-39	0	0	0	0	-
		Change in Soil Moisture Deficit (mm)	0	0	1	31	29	12	-2	-31	-39	0	0	0	-
		Precipitation Surplus (mm)	50	34	0	0	0	0	0	0	35	58	60	50	**288**
		MOECC Infiltration Factor	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
		Run-Off Coefficient	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-
		Infiltration (mm)	30	21	0	0	0	0	0	0	21	35	36	30	**173**
		Run-Off (mm)	20	14	0	0	0	0	0	0	14	23	24	20	**115**
		Catchment Area (m^2) = 23000.00						**Subcatchment Monthly Volumes**							
		Infiltration (m^3)	694	475	0	0	0	0	0	0	488	796	834	693	**3981**
		Run-Off (m^3)	463	317	0	0	0	0	0	0	326	531	556	462	**2654**
	Pervious Area-Landscape/Urban Lawn-Clay Loam	**Soil Moisture Storage (mm)**	100	100	99	64	16	0	2	33	100	100	100	100	-
		Actual Potential Evapotranspiration (mm)	0	33	77	104	101	80	73	37	8	0	0	0	**513**
		P-AET (mm)	50	34	-1	-29	-19	-3	2	31	74	58	60	50	-
		Actual Soil Moisture Deficit (mm)	0	0	-1	-30	-49	-52	-50	-18	0	0	0	0	-
		Change in Soil Moisture Deficit (mm)	0	0	1	29	19	3	-2	-31	-18	0	0	0	-
		Precipitation Surplus (mm)	50	34	0	0	0	0	0	0	56	58	60	50	**309**
		MOECC Infiltration Factor	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
		Run-Off Coefficient	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	-
		Infiltration (mm)	25	17	0	0	0	0	0	0	28	29	30	25	**154**
		Run-Off (mm)	25	17	0	0	0	0	0	0	28	29	30	25	**154**
		Catchment Area (m^2) = 10500.00						**Subcatchment Monthly Volumes**							
		Infiltration (m^3)	264	181	0	0	0	0	0	0	293	303	317	264	**1622**
		Run-Off (m^3)	264	181	0	0	0	0	0	0	293	303	317	264	**1622**
	Pervious Area-Mature Forests-Fine Sandy Loam	**Soil Moisture Storage (mm)**	300	300	299	264	216	180	181	213	287	300	300	300	-
		Actual Potential Evapotranspiration (mm)	0	33	77	109	120	102	73	37	8	0	0	0	**557**
		P-AET (mm)	50	34	-1	-33	-38	-24	2	31	74	58	60	50	-
		Actual Soil Moisture Deficit (mm)	0	0	-1	-34	-72	-96	-94	-63	0	0	0	0	-
		Change in Soil Moisture Deficit (mm)	0	0	1	33	38	24	-2	-31	-63	0	0	0	-
		Precipitation Surplus (mm)	50	34	0	0	0	0	0	0	11	58	60	50	**264**
		MOECC Infiltration Factor	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
		Run-Off Coefficient	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-
		Infiltration (mm)	30	21	0	0	0	0	0	0	7	35	36	30	**159**
		Run-Off (mm)	20	14	0	0	0	0	0	0	4	23	24	20	**106**
		Catchment Area (m^2) = 30500.00						**Subcatchment Monthly Volumes**							
		Infiltration (m^3)	920	631	0	0	0	0	0	0	205	1056	1105	919	**4836**
		Run-Off (m^3)	614	420	0	0	0	0	0	0	137	704	737	612	**3224**

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TABLE A-2

Pre-development Water Balance

Water Balance Analysis - Graham Property

Catchments and Hydrologic Components		Month												Total
		March	April	May	June	July	August	September	October	November	December	January	February	
	PET - Adjusted Potential Evapotranspiration (mm)	0	33	77	111	129	114	73	37	8	0	0	0	**581**
	P - Total Precipitation (mm)	50	67	76	76	82	77	75	68	82	58	60	50	**821**
	P-PET (mm)	50	34	-1	-35	-47	-37	2	31	74	58	60	50	-
	Soil Moisture Deficit (mm)	0	0	-1	-36	-84	-120	-119	-87	-13	0	0	0	-
Impervious Area Driveway/ Road/ Paved Surface	Precipitation Surplus (mm)	50	67	76	76	82	77	75	68	82	58	60	50	**821**
	Evaporation Factor	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-
	Run-Off Coefficient	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	-
	Evaporation (mm)	8	10	11	11	12	12	11	10	12	9	9	8	**123**
	Run-Off (mm)	43	57	65	64	70	66	64	58	69	49	51	43	**698**
	Catchment Area (m^2) = 2000.00					**Subcatchment Monthly Volumes**								
	Evaporation (m^3)	15	20	23	23	25	23	23	20	25	17	18	15	**246**
	Run-Off (m^3)	86	114	129	128	139	132	128	116	139	98	103	85	**1396**
						Total Catchment Volumes								
	Total AET (m^3)	0	9764	23078	31972	33290	27052	21944	11049	2261	0	0	0	**160409**
	Total Evaporation (m^3)	15	20	23	23	25	23	23	20	25	17	18	15	246
	Total Infiltration (m^3)	7814	5353	0	0	0	0	0	0	5163	8964	9383	7799	44475
	Total Runoff (m^3)	6768	4691	129	128	139	132	128	116	4938	7764	8127	6754	42932

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TABLE A-3

Post-development Water Balance

Water Balance Analysis- Graham Property

Catchments and Hydrologic Components			March	April	May	June	July	August	September	October	November	December	January	February	Total
		PET - Adjusted Potential Evapotranspiration (mm)	0	33	77	111	129	114	73	37	8	0	0	0	**581**
		P - Total Precipitation (mm)	50	67	76	76	82	77	75	68	82	58	60	50	**821**
		P-PET (mm)	50	34	-1	-35	-47	-37	2	31	74	58	60	50	-
		Soil Moisture Deficit (mm)	0	0	-1	-36	-84	-120	-119	-87	-13	0	0	0	-
Graham Property	Pervious Area-Mature Forests-Fine Sandy Loam	**Soil Moisture Storage (mm)**	300	300	299	264	216	180	181	213	287	300	300	300	-
		Actual Potential Evapotranspiration (mm)	0	33	77	109	120	102	73	37	8	0	0	0	**557**
		P-AET (mm)	50	34	-1	-33	-38	-24	2	31	74	58	60	50	-
		Actual Soil Moisture Deficit (mm)	0	0	-1	-34	-72	-96	-94	-63	0	0	0	0	-
		Change in Soil Moisture Deficit (mm)	0	0	1	33	38	24	-2	-31	-63	0	0	0	-
		Precipitation Surplus (mm)	50	34	0	0	0	0	0	0	11	58	60	50	**264**
		MOECC Infiltration Factor	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
		Run-Off Coefficient	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-
		Infiltration (mm)	30	21	0	0	0	0	0	0	7	35	36	30	**159**
		Run-Off (mm)	20	14	0	0	0	0	0	0	4	23	24	20	**106**
		Catchment Area (m^2) = 149000.00					**Subcatchment Monthly Volumes**								
		Infiltration (m^3)	4497	3080	0	0	0	0	0	0	1001	5158	5400	4488	**23625**
		Run-Off (m^3)	2998	2053	0	0	0	0	0	0	668	3439	3600	2992	**15750**
	Pervious Area-Landscape/ Urban Lawn-Clay Loam	**Soil Moisture Storage (mm)**	100	100	99	64	16	0	2	33	100	100	100	100	-
		Actual Potential Evapotranspiration (mm)	0	33	77	104	101	80	73	37	8	0	0	0	**513**
		P-AET (mm)	50	34	-1	-29	-19	-3	2	31	74	58	60	50	-
		Actual Soil Moisture Deficit (mm)	0	0	-1	-30	-49	-52	-50	-18	0	0	0	0	-
		Change in Soil Moisture Deficit (mm)	0	0	1	29	19	3	-2	-31	-18	0	0	0	-
		Precipitation Surplus (mm)	50	34	0	0	0	0	0	0	56	58	60	50	**309**
		MOECC Infiltration Factor	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
		Run-Off Coefficient	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	-
		Infiltration (mm)	23	16	0	0	0	0	0	0	25	26	27	23	**139**
		Run-Off (mm)	28	19	0	0	0	0	0	0	31	32	33	28	**170**
		Catchment Area (m^2) = 121000.00					**Subcatchment Monthly Volumes**								
		Infiltration (m^3)	2739	1876	0	0	0	0	0	0	3039	3142	3289	2733	**16817**
		Run-Off (m^3)	3347	2293	0	0	0	0	0	0	3714	3840	4020	3341	**20555**
	Impervious Area-Buildings (Roofs)	**Precipitation Surplus (mm)**	50	67	76	76	82	77	75	68	82	58	60	50	**821**
		Evaporation Factor	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-
		Run-Off Coefficient	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	-
		Evaporation (mm)	8	10	11	11	12	12	11	10	12	9	9	8	**123**
		Run-Off (mm)	43	57	65	64	70	66	64	58	69	49	51	43	**698**
		Catchment Area (m^2) = 14000.00					**Subcatchment Monthly Volumes**								
		Evaporation (m^3)	106	141	160	159	172	163	158	143	172	121	127	105	**1725**
		Run-Off (m^3)	599	797	906	898	973	921	893	813	972	687	719	597	**9775**

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TABLE A-3

Post-development Water Balance

Water Balance Analysis- Graham Property

Catchments and Hydrologic Components		Month												Total
		March	April	May	June	July	August	September	October	November	December	January	February	
	PET - Adjusted Potential Evapotranspiration (mm)	0	33	77	111	129	114	73	37	8	0	0	0	**581**
	P - Total Precipitation (mm)	50	67	76	76	82	77	75	68	82	58	60	50	**821**
	P-PET (mm)	50	34	-1	-35	-47	-37	2	31	74	58	60	50	-
	Soil Moisture Deficit (mm)	0	0	-1	-36	-84	-120	-119	-87	-13	0	0	0	-
Impervious Area Driveway/ Road/ Paved Surface	**Precipitation Surplus (mm)**	50	67	76	76	82	77	75	68	82	58	60	50	**821**
	Evaporation Factor	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-
	Run-Off Coefficient	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	-
	Evaporation (mm)	8	10	11	11	12	12	11	10	12	9	9	8	**123**
	Run-Off (mm)	43	57	65	64	70	66	64	58	69	49	51	43	**698**
	Catchment Area (m^2) = 18000.00					**Subcatchment Monthly Volumes**								
	Evaporation (m^3)	136	181	205	204	221	209	203	184	221	156	163	136	**2218**
	Run-Off (m^3)	770	1025	1164	1155	1252	1184	1148	1045	1250	883	924	768	**12567**
						Total Catchment Volumes								
	Total AET (m^3)	0	8787	20770	28797	30056	24894	19750	9944	2035	0	0	0	145032
	Total Evaporation (m^3)	241	322	365	362	393	372	360	328	392	277	290	241	**3943**
	Total Infiltration (m^3)	7236	4956	0	0	0	0	0	0	4040	8300	8689	7221	40442
	Total Runoff (m^3)	7714	6169	2070	2054	2225	2105	2040	1858	6604	8848	9262	7698	58646

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